Probing confined photons in nanoscale disordered media from inside

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A substantial effort is devoted to the understanding of light scattering in disordered materials, both for fundamental studies in mesoscopic physics and for applications (imaging with diffuse light, design of novel photonic materials). Standard measurements involve averaged transmitted or reflected intensity, or fluctuations (speckles). In this talk we show that probing photonic properties of nanoscale disordered media from inside reveals important features, in particular the interplay between multiple scattering and near-field interactions. This can be achieved by studying the fluorescence dynamics of nanosources placed inside the medium.

Modifications of the spontaneous decay rate (or fluorescence lifetime) of dipole nanosources can be understood from changes in the local density of photonic states (LDOS). The statistical distribution of the decay rate (or LDOS) in a disordered medium structured at the nanoscale exhibits a long tail, giving rise to large fluctuations. The long tail corresponds to substantial changes in the LDOS (or equivalently to large Purcell factors) produced by rare events. The analysis of the statistical distributions reveals different interaction regimes [1,2], and puts forward the influence of short-range near-field scattering [3]. Experiments performed on disordered metallic films [4] reveal the existence of spatially localized modes produced by the interplay between disorder and plasmon resonances (see Fig. 1). Large Purcell factors are also observed in strongly scattering dielectric powders, and can be attributed to confined photonic modes produced by near-field scattering [5].

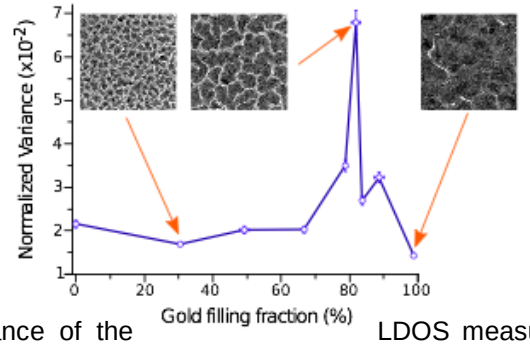

Fig. 1 Normalized variance of the LDOS measured on disordered gold films with different surface fractions. The peak in the LDOS fluctuations is a signature of localized plasmon modes. The insets show TEM images of a few samples. Adapted from [4].

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